US010024164B2

(12) **United States Patent**
Miller et al.

(10) **Patent No.: US 10,024,164 B2**
(45) **Date of Patent: Jul. 17, 2018**

(54) **FIXTURE FOR RESTRAINING A TURBINE WHEEL**

(71) Applicant: **General Electric Company**, Schenectady, NY (US)

(72) Inventors: **Maxwell Evan Miller**, Simpsonville, SC (US); **Jason Matthew Clark**, Maryville, TN (US); **Sandra Beverly Kolvick**, Simpsonville, SC (US)

(73) Assignee: **General Electric Company**, Schenectady, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 23 days.

(21) Appl. No.: **15/277,327**

(22) Filed: **Sep. 27, 2016**

(65) **Prior Publication Data**

US 2018/0087383 A1 Mar. 29, 2018

(51) **Int. Cl.**
F01D 5/00 (2006.01)
F01D 5/30 (2006.01)
F01D 5/32 (2006.01)

(52) **U.S. Cl.**
CPC ***F01D 5/005*** (2013.01); ***F01D 5/3007*** (2013.01); ***F01D 5/32*** (2013.01); *F05D 2220/32* (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC Y10T 403/7094; Y10T 403/70; F01D 25/243; F01D 25/285; F01D 5/02;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,721,506 A * 3/1973 Anderson F01D 5/3038 416/215
4,630,982 A * 12/1986 Fenner ..... B61D 45/001 24/265 CD
(Continued)

FOREIGN PATENT DOCUMENTS

EP 2 752 382 A1 7/2014
EP 2 921 657 A1 9/2015
(Continued)

OTHER PUBLICATIONS

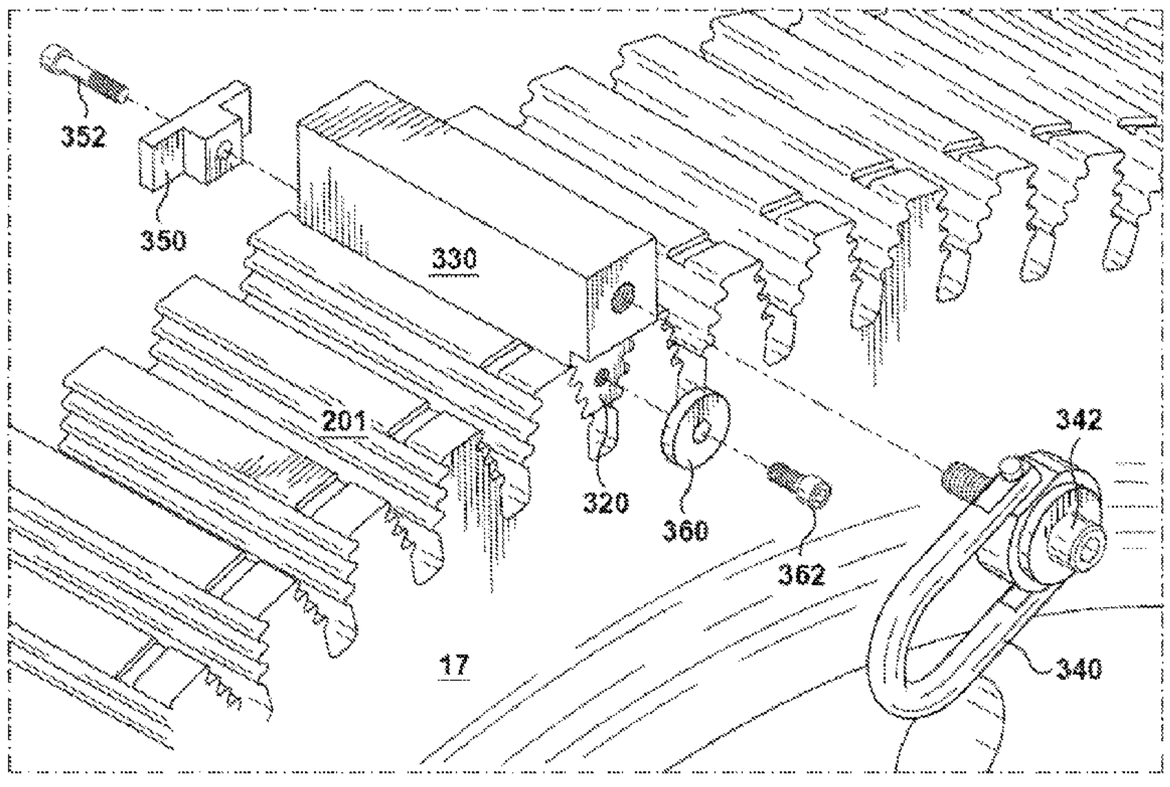
International Search Report and Written Opinion issued in connection with corresponding PCT Application No. PCT/US2017/049106 dated Nov. 14, 2017.

Primary Examiner — Josh Skroupa
Assistant Examiner — Cory B Siegert
(74) *Attorney, Agent, or Firm* — James W. Pemrick; Ernest G. Cusick; Frank A. Landgraff

(57) **ABSTRACT**

A fixture for restraining a wheel of a turbomachine has a dovetail section adapted for insertion into a dovetail slot of the wheel. A mounting section is located adjacent to, or formed integrally with, the dovetail section. At least one coupling ring is attached to the mounting section, and the coupling ring is adapted to be secured to a stationary anchoring point via a restraint. The stationary anchoring point includes at least one counterbore assembly having a coupling ring attached thereto. The counterbore assembly is adapted to be secured to a stationary structure. The stationary structure may be a shell, a flange or a casing of the turbomachine.

7 Claims, 8 Drawing Sheets



(52) **U.S. Cl.**
CPC *F05D 2230/72* (2013.01); *F05D 2260/02* (2013.01); *F05D 2260/30* (2013.01)

(58) **Field of Classification Search**
CPC F01D 2220/32; F05D 2260/30; F05D 2230/60; F05D 2230/72; F05D 2230/68; F05D 2230/80; B27F 1/08; E04B 2/08; E04B 2/18; E04B 2/32; E04B 2/46; E04B 2001/2624; E04B 2001/2628; E04B 2001/2632; E04B 2002/0252; F04D 29/644; F05B 2260/30; F05B 2230/60; F05B 2230/61; F05B 2230/80; A47B 2230/0077
USPC 403/381, 345
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,284,406	A	2/1994	Mueller et al.	
6,016,600	A *	1/2000	Kennell	B23P 6/002 29/889.1
6,638,006	B2 *	10/2003	Selby	F01D 5/3038 415/9
8,267,664	B2 *	9/2012	Tipton	F01D 5/326 416/220 A
8,414,268	B2 *	4/2013	Aiello	F01D 5/32 416/215
9,429,041	B2 *	8/2016	Holmes	B25B 27/14
9,745,995	B2 *	8/2017	Jevons	F04D 29/34
2015/0110635	A1 *	4/2015	Kain	F01D 5/3007 416/221
2016/0201556	A1 *	7/2016	Kolvick	F01D 5/3007 29/888.012
2017/0030222	A1 *	2/2017	De Sousa	F01D 25/162
2017/0218973	A1 *	8/2017	Bishop	F04D 29/30

FOREIGN PATENT DOCUMENTS

KR	10-2012-0092336	A	8/2012	
WO	WO-2015110749	A1 *	7/2015	F01D 25/162

* cited by examiner

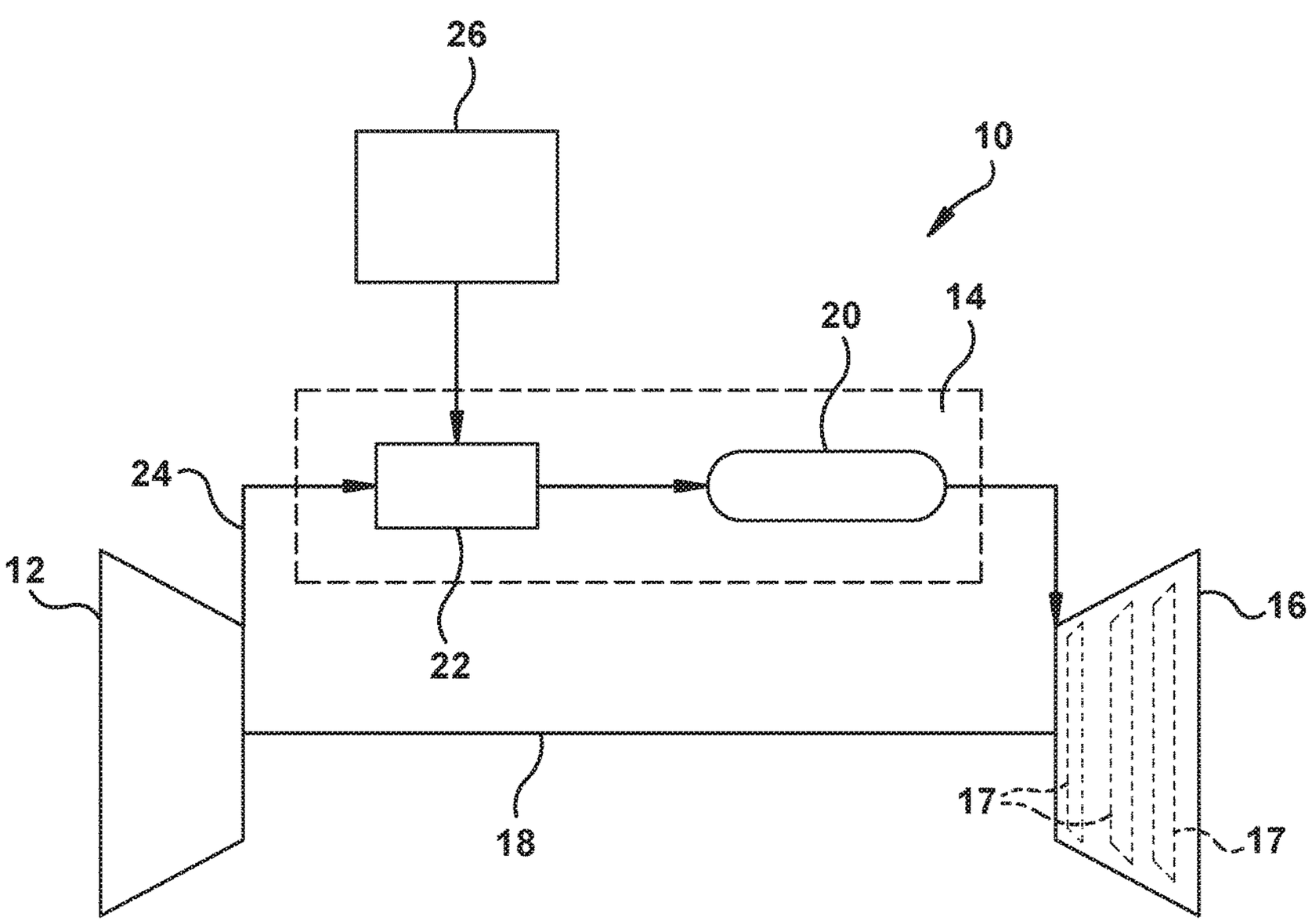


FIG. 1

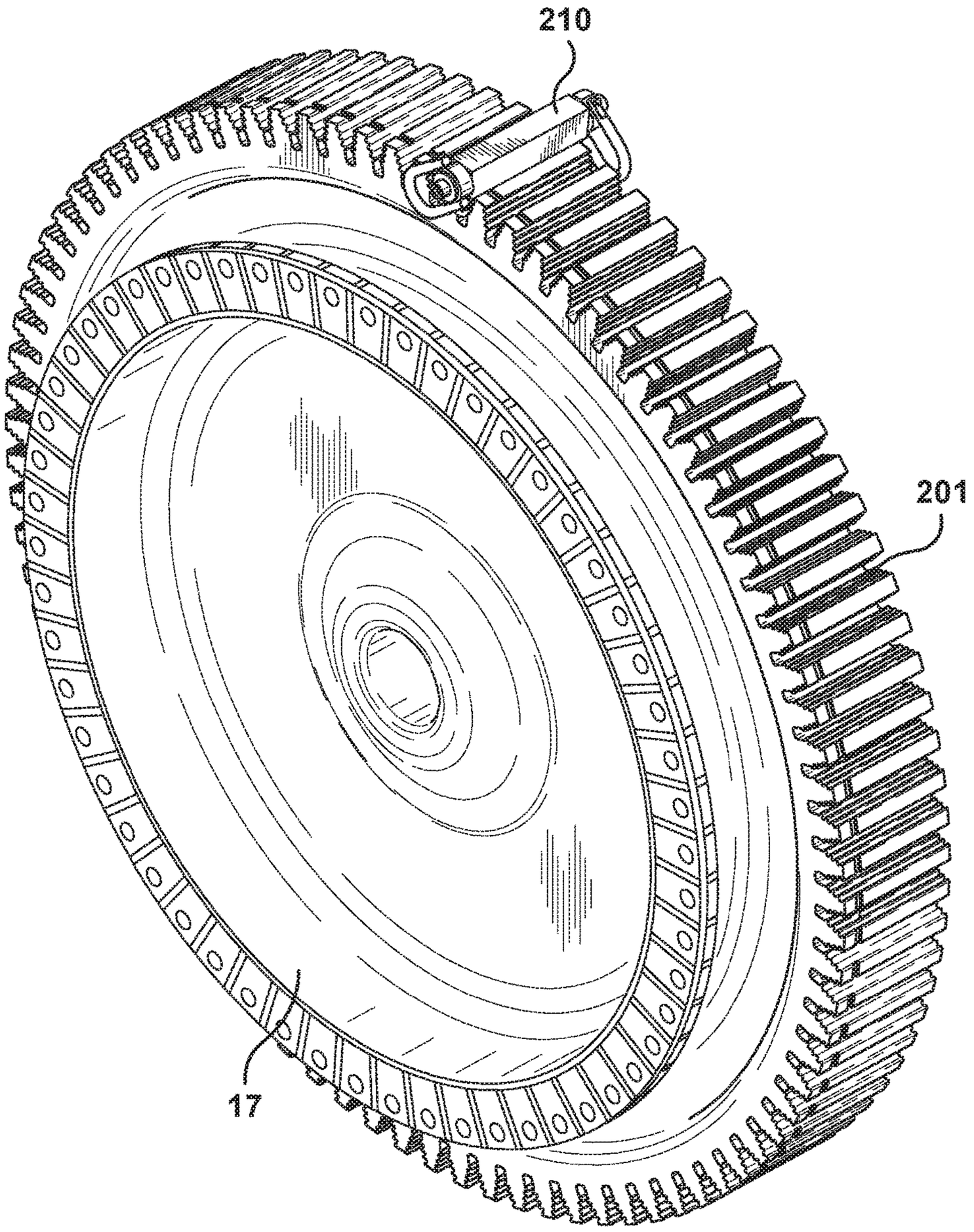


FIG. 2

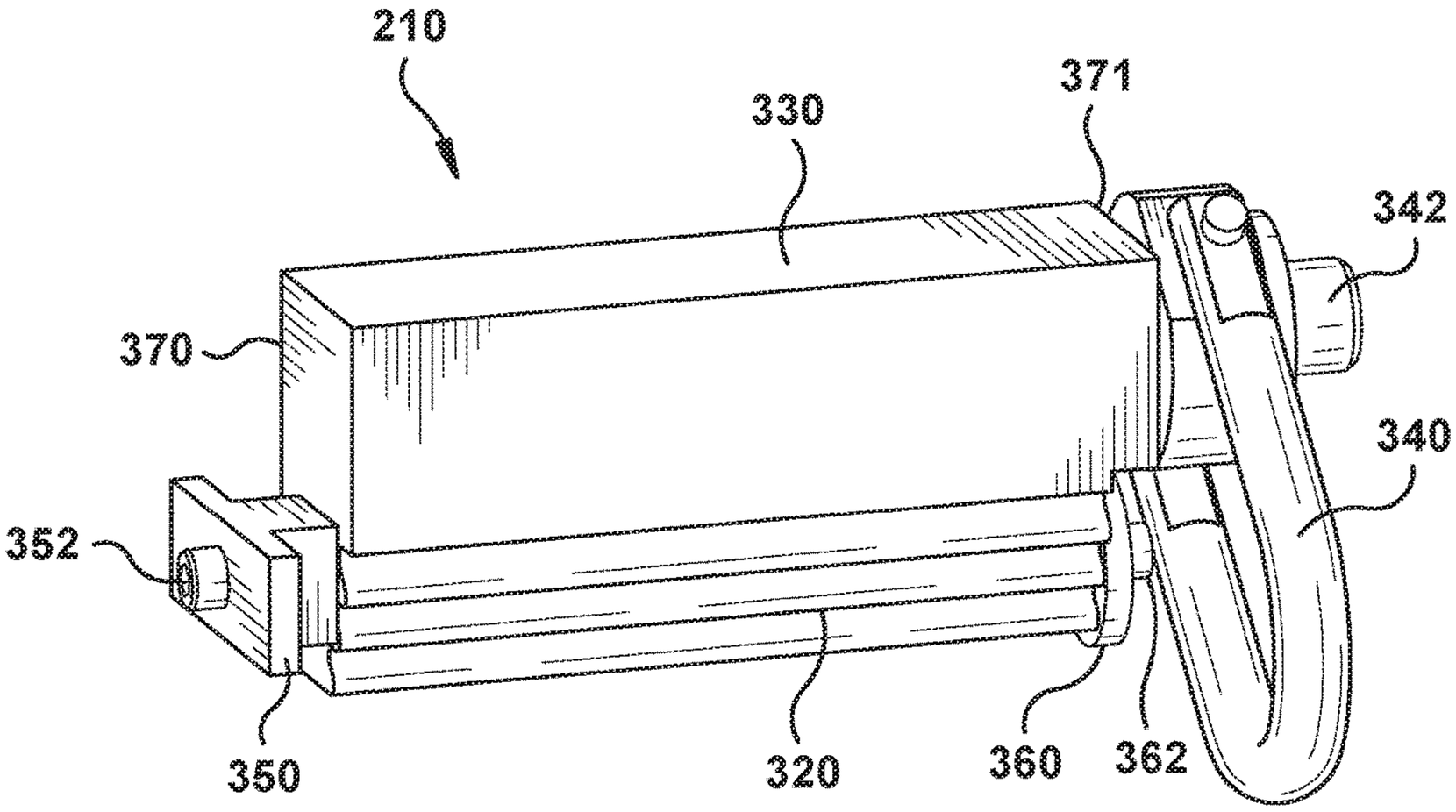

210
330
371
342
370
340
352
350
320
360
362

FIG. 3

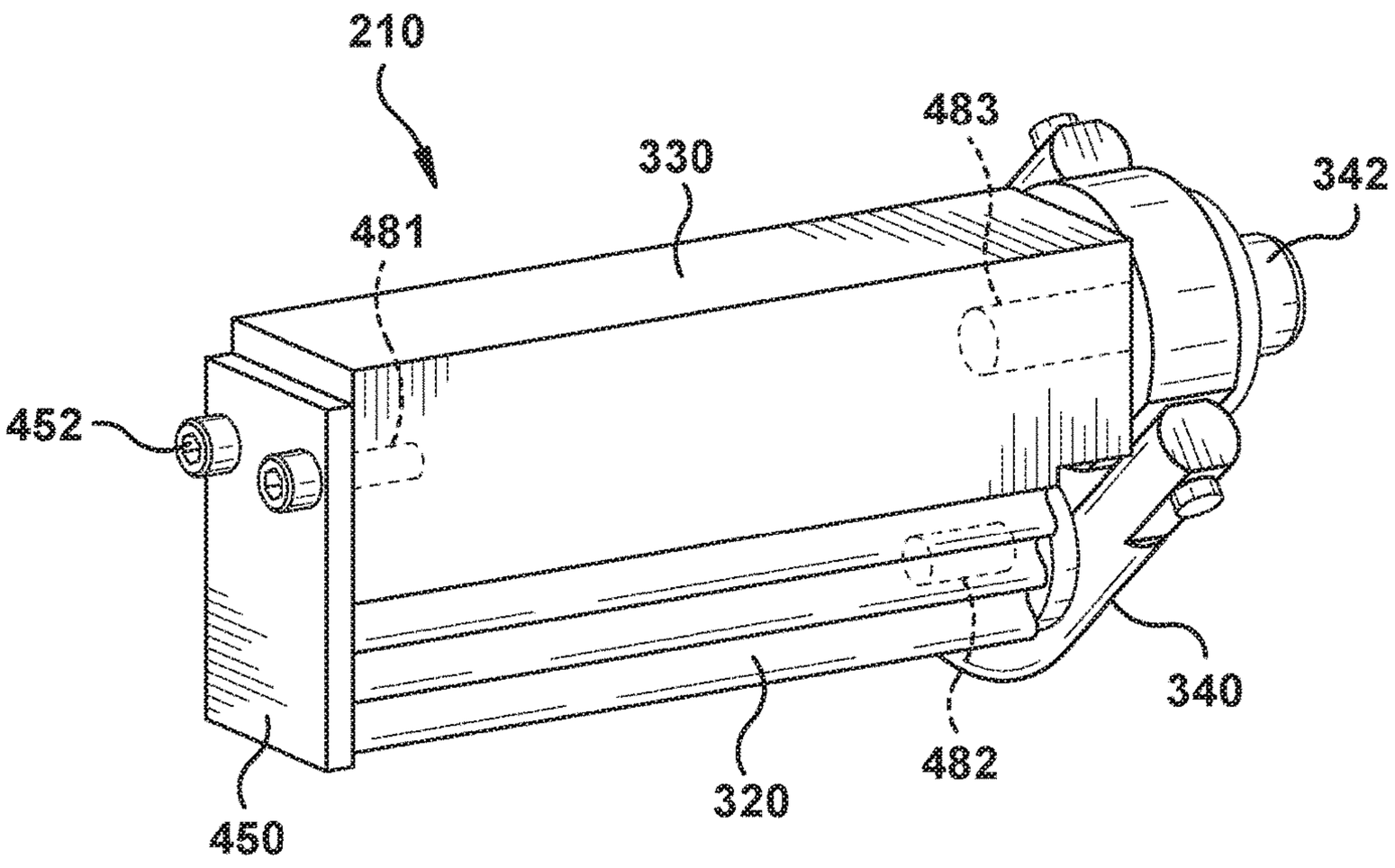

210
483
330
342
481
452
340
320
482
450

FIG. 4

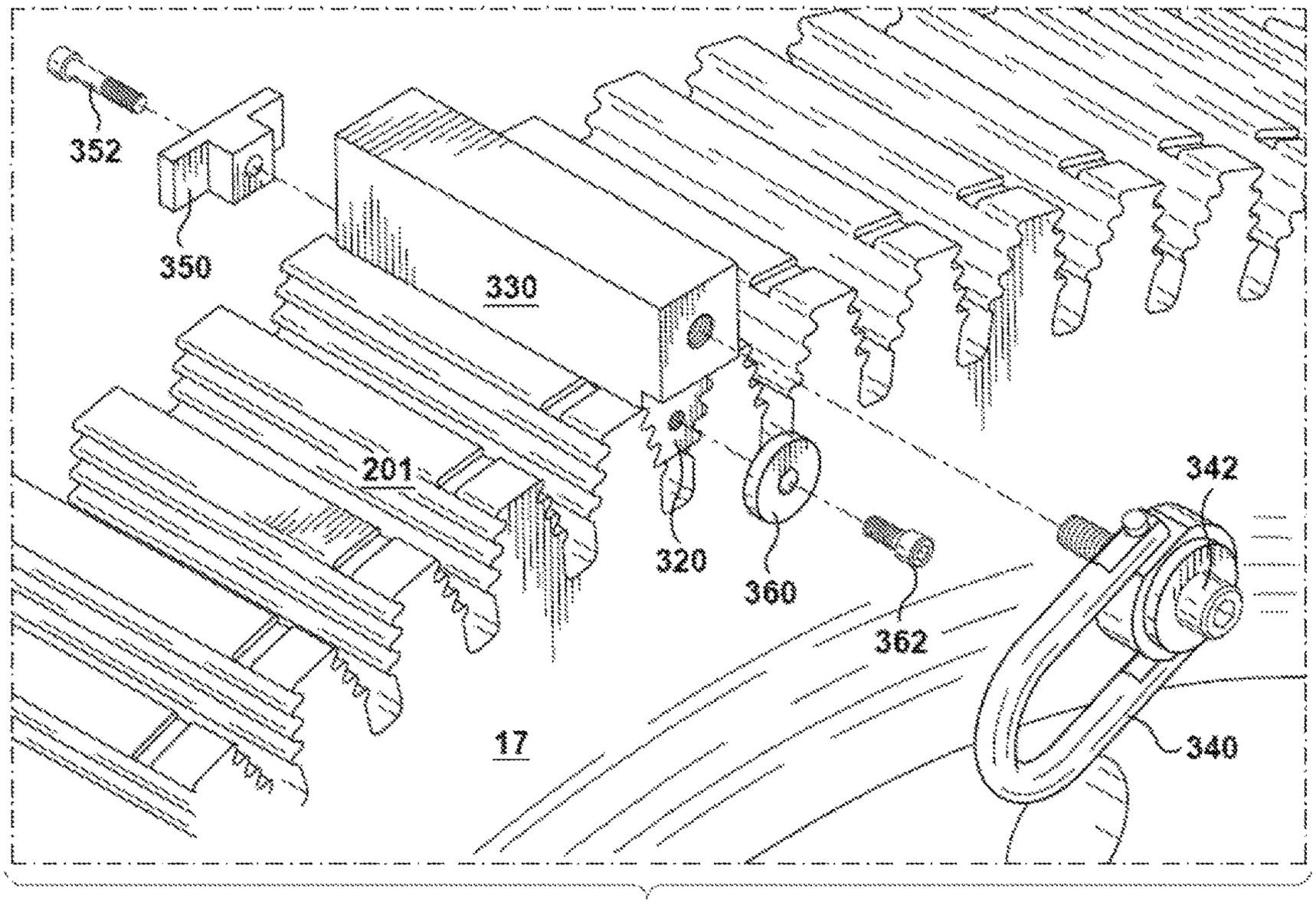


FIG. 5

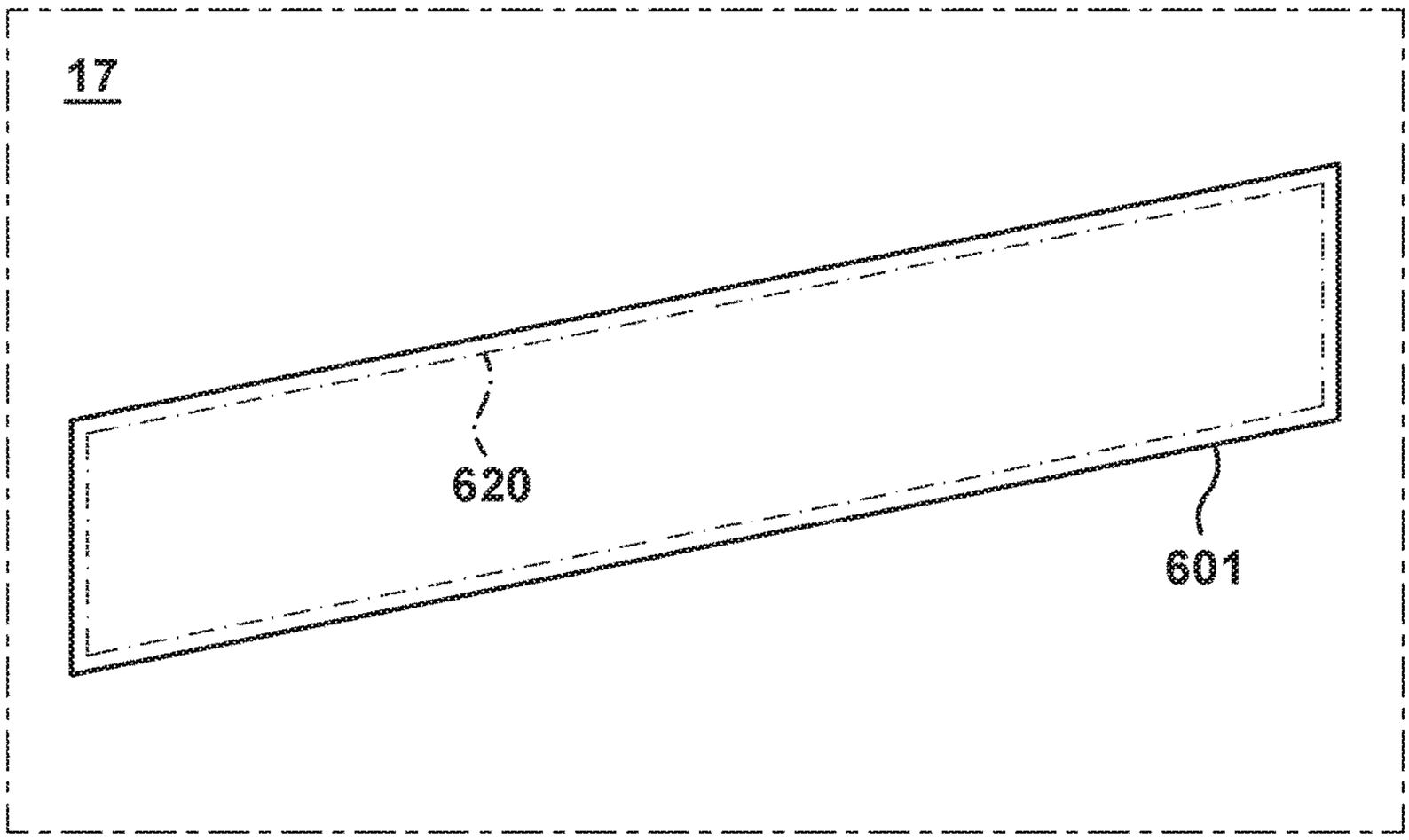


FIG. 6

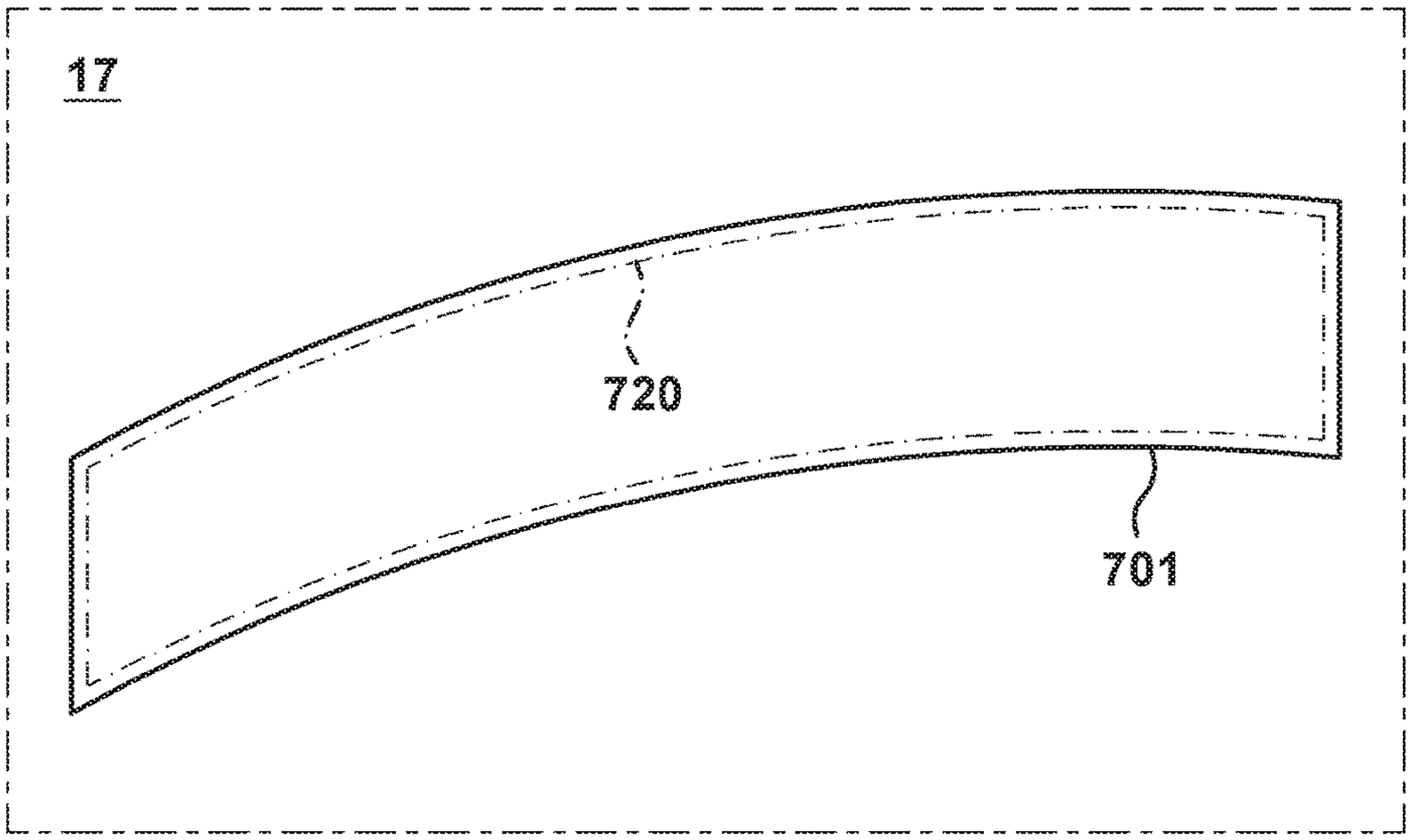


FIG. 7

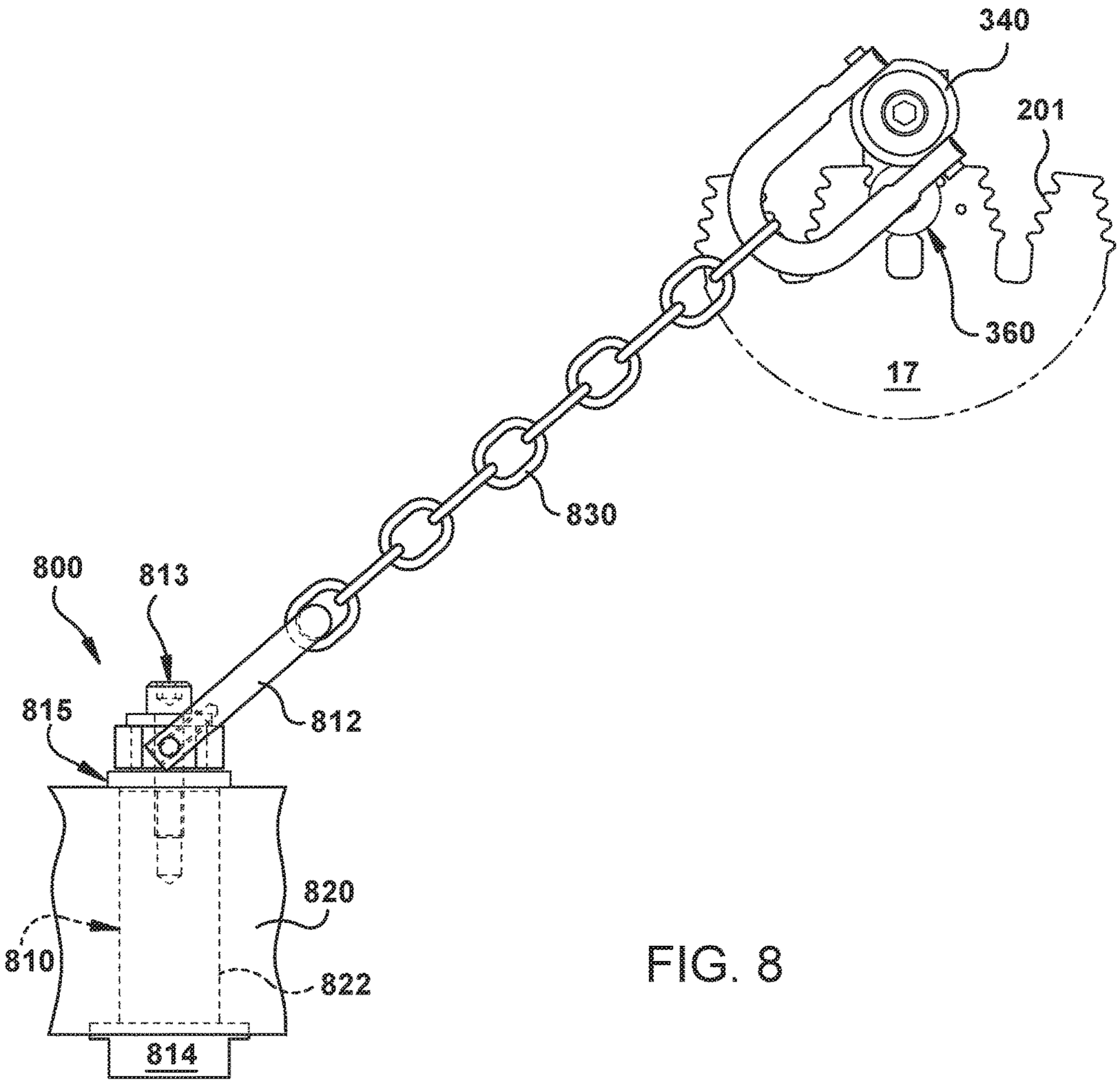


FIG. 8

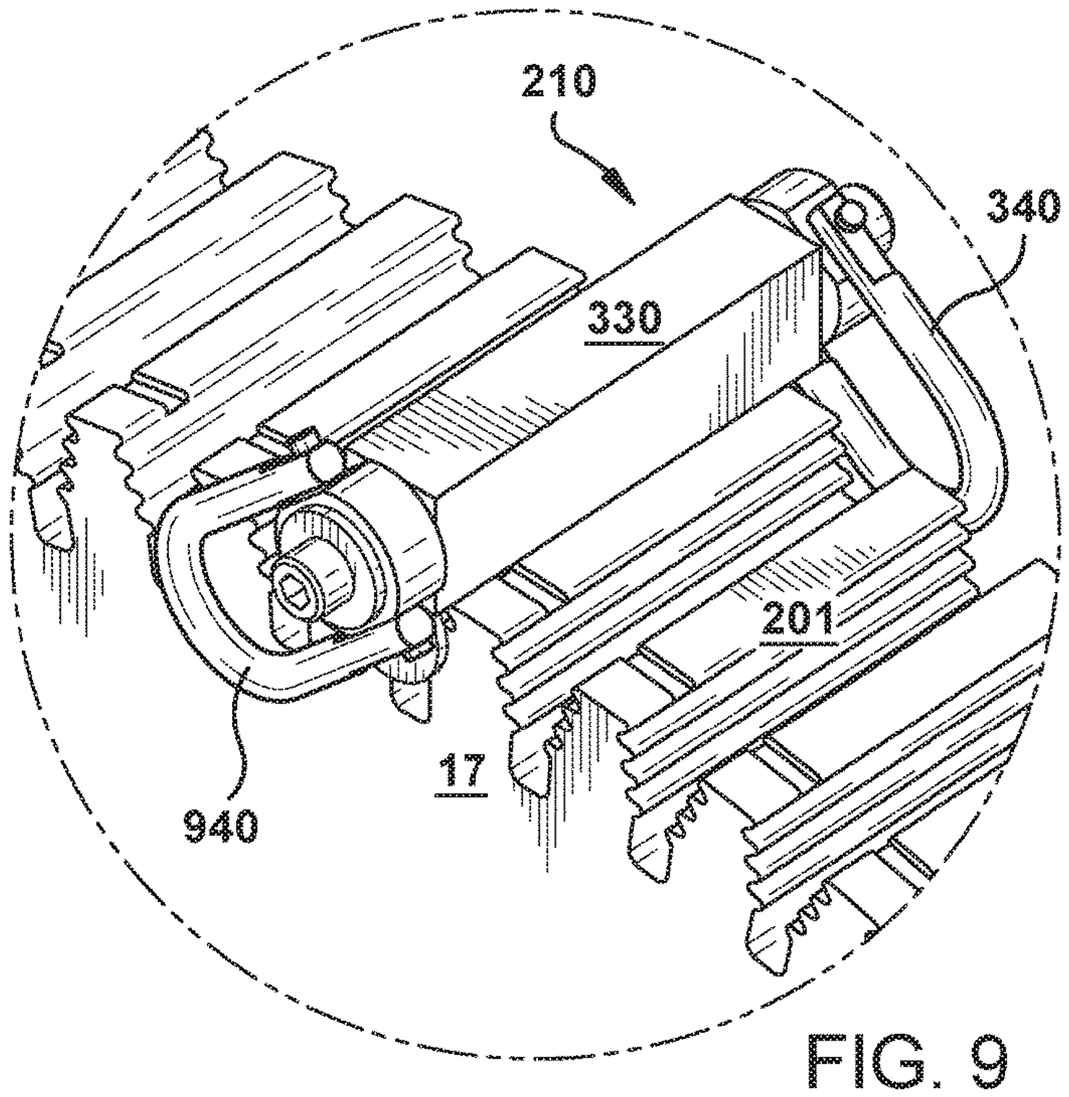

210
340
330
201
17
940

FIG. 9

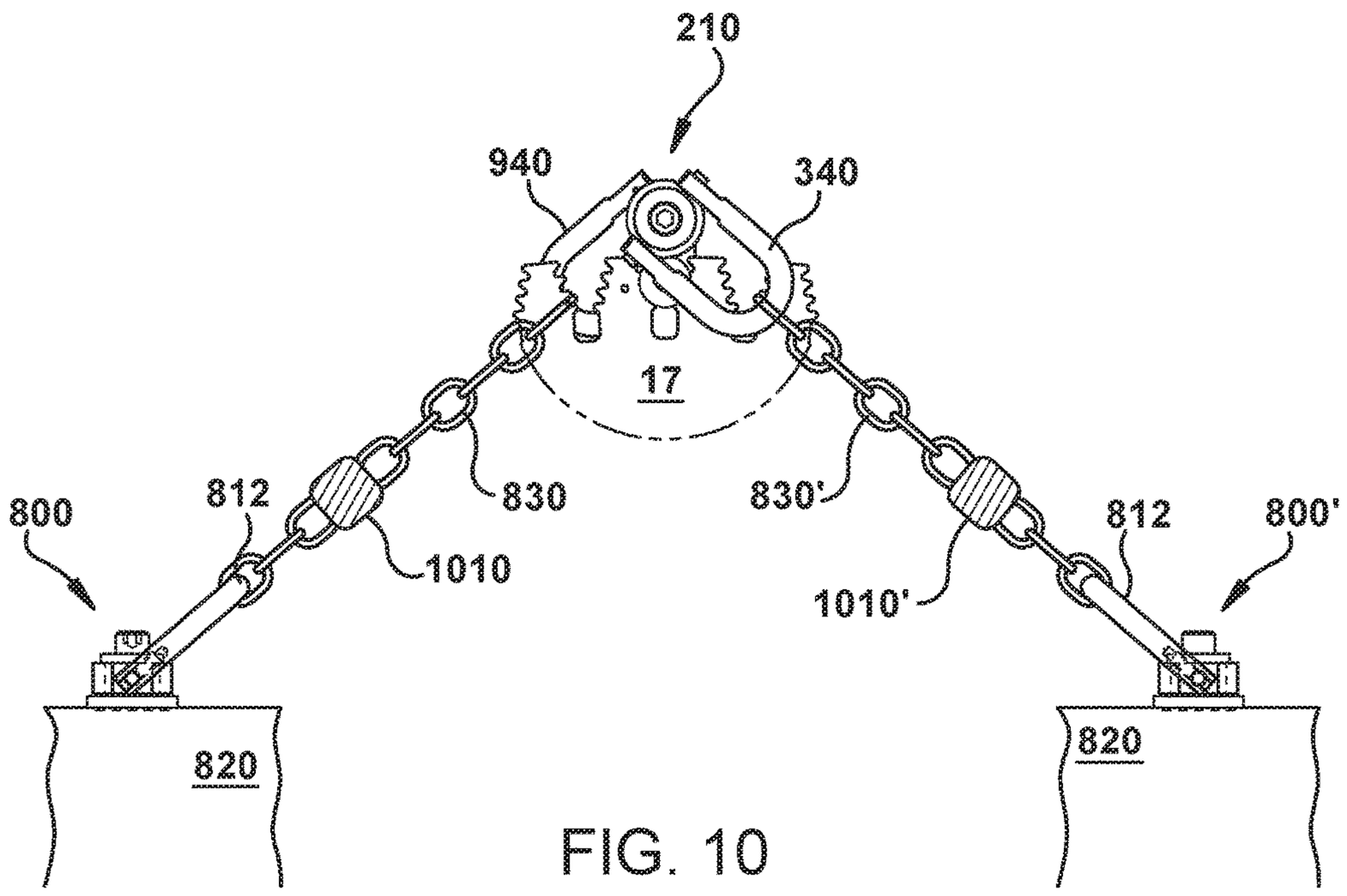

210
940
340
17
830
812
800
1010
830'
812
800'
1010'
820
820

FIG. 10

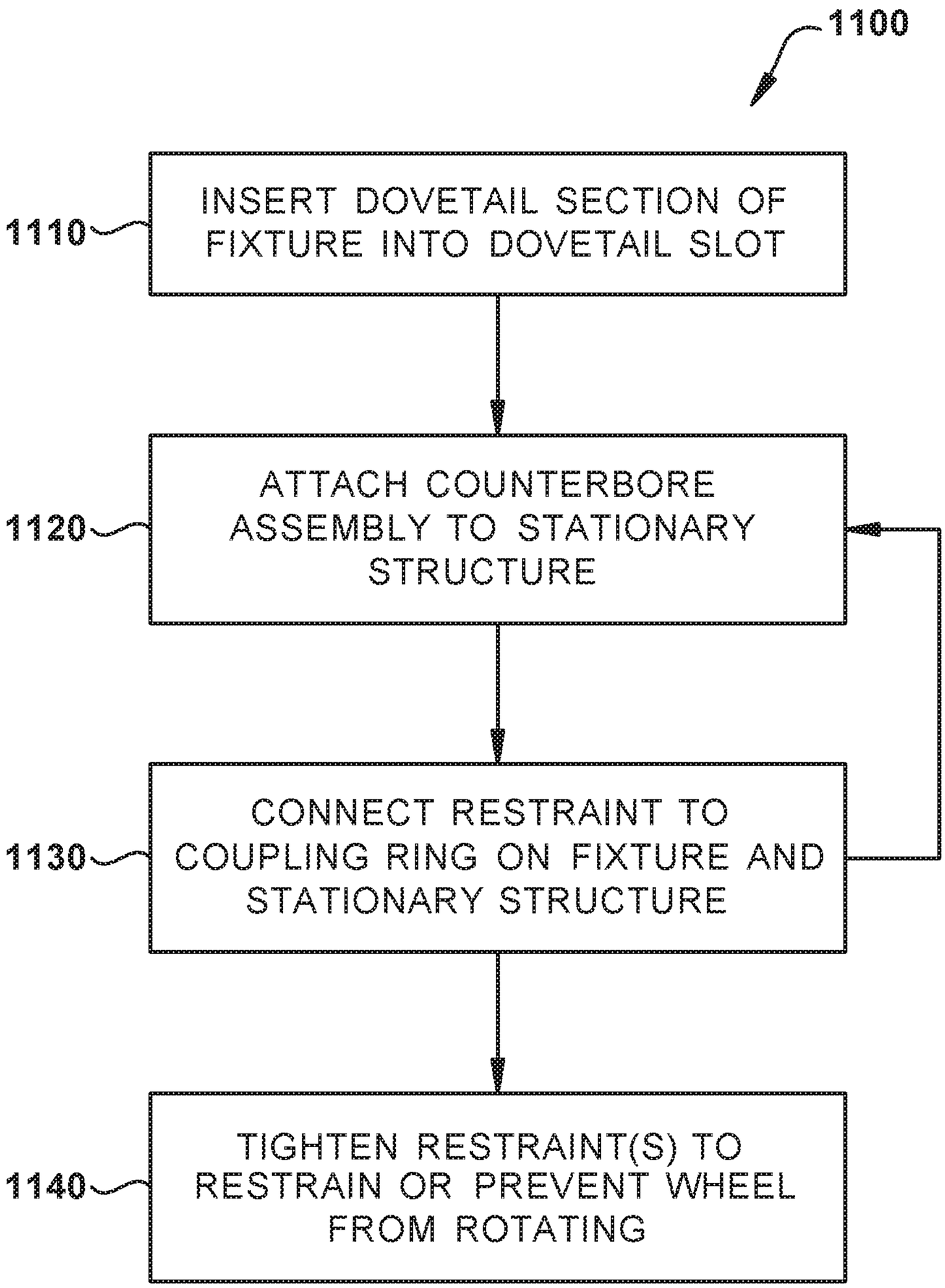

1100
1110
INSERT DOVETAIL SECTION OF FIXTURE INTO DOVETAIL SLOT
1120
ATTACH COUNTERBORE ASSEMBLY TO STATIONARY STRUCTURE
1130
CONNECT RESTRAINT TO COUPLING RING ON FIXTURE AND STATIONARY STRUCTURE
1140
TIGHTEN RESTRAINT(S) TO RESTRAIN OR PREVENT WHEEL FROM ROTATING

FIG. 11

FIXTURE FOR RESTRAINING A TURBINE WHEEL

BACKGROUND OF THE INVENTION

The apparatus described herein relates generally to turbomachinery and, more specifically, to a fixture for restraining a turbine wheel during a blade removal or installation procedure.

Turbomachines need regular maintenance to keep up with the cycle type, in which some cases are continuous (6,000 hours/year or more). During an inspection maintenance outage, the blades in the turbine section of the turbomachine may need to be replaced. The top half of the turbine case is removed, and technicians will restrain the rotor from rolling and begin to remove or replace the turbine blades. To restrain the rotor, technicians have tied a strap around a blade and then attached it to somewhere in the turbine compartment. This known method could result in near miss or incidents which involve the rotor rolling due to a broken strap, as well as damage caused to the blade. The known method that uses a strap presents a risk of injury, safety concerns, as well as requiring possible replacement parts due to hardware damage.

BRIEF DESCRIPTION OF THE INVENTION

In an aspect of the present invention, a fixture for restraining a wheel of a turbomachine has a dovetail section adapted for insertion into a dovetail slot of the wheel. A mounting section is located adjacent to, or formed integrally with, the dovetail section. At least one coupling ring is attached to the mounting section, and the at least one coupling ring is adapted to be secured to a stationary anchoring point via a restraint.

In another aspect of the present invention, a fixture for restraining a wheel of a turbomachine includes a dovetail section adapted for insertion into a dovetail slot of the wheel. The dovetail section has a dovetail shaped profile or fir tree shaped profile adapted to interlock with corresponding notches or recesses in the dovetail slot of the wheel. The dovetail section has an aft end and a forward end, and both the aft end and the forward end have a threaded hole adapted for securing a fastener. A mounting section is located adjacent to, or formed integrally with, the dovetail section. The mounting section has at least one threaded hole adapted for attaching a coupling ring to the mounting section. A coupling fastener and a washer secures the coupling ring to the mounting section via the at least one threaded hole. The coupling ring is attached to the mounting section, and the at least one coupling ring is adapted to be secured to a stationary anchoring point via a restraint.

In yet another aspect of the present invention, a method for restraining a wheel of a turbomachine is provided. The method includes a step of inserting a fixture into a dovetail slot in the wheel. The fixture has dovetail section adapted for insertion into the dovetail slot, and a mounting section located adjacent to, or formed integrally with, the dovetail section. The mounting section is adapted to connect to at least one coupling ring. The inserting step may also include placing a washer over a fastener, and inserting the fastener into a threaded hole in the dovetail section, wherein the washer is adapted to extend over an axial face of the dovetail slot. In addition, the inserting step may include attaching the at least one coupling ring to the mounting section. An attaching step attaches at least one counterbore assembly to a stationary structure, and a connecting step connects a restraint to the at least one coupling ring and the at least one counterbore assembly. The connecting step may also include attaching a come-along or ratcheting mechanism having a strap, chain or cable to both the at least one coupling ring and the at least one counterbore assembly, and tightening the come-along or ratcheting mechanism to restrain the wheel. The stationary structure may be a shell, a flange or a casing of the turbomachine. The dovetail section may have a straight profile adapted for use with a straight dovetail slot, or an angled profile adapted for use with an angled dovetail slot, or a curved profile adapted for use with a curved dovetail slot.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic illustration of a gas turbine system;

FIG. **2** illustrates a perspective view of single turbine wheel;

FIG. **3** illustrates a perspective view of a fixture for restraining a wheel of a turbomachine, according to an aspect of the present invention;

FIG. **4** illustrates a perspective view of the fixture for restraining a wheel of a turbomachine, according to an aspect of the present invention;

FIG. **5** illustrates an exploded, perspective view of the fixture in a dovetail slot of a wheel, according to an aspect of the present invention;

FIG. **6** illustrates a top, cross-sectional view of the fixture located in a dovetail slot;

FIG. **7** illustrates a top, cross-sectional view of the fixture located in a curved, axial-entry type of dovetail slot;

FIG. **8** illustrates a partial side view of the fixture installed in a wheel and connected to a stationary anchoring point on the turbomachine's casing;

FIG. **9** illustrates a perspective view of the fixture located in a dovetail slot of a wheel of a turbomachine;

FIG. **10** illustrates a partial side view of the fixture of FIG. **9** installed in a dovetail slot of wheel, and the fixture is connected to two stationary anchoring points on the turbomachine's casing; and

FIG. **11** is a flowchart for a method for restraining a wheel of a turbomachine.

DETAILED DESCRIPTION OF THE INVENTION

One or more specific aspects/embodiments of the present invention will be described below. In an effort to provide a concise description of these aspects/embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with machine-related, system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

When introducing elements of various embodiments of the present invention, the articles "a," "an," and "the" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be addi-

tional elements other than the listed elements. Any examples of operating parameters and/or environmental conditions are not exclusive of other parameters/conditions of the disclosed embodiments. Additionally, it should be understood that references to "one embodiment", "one aspect" or "an embodiment" or "an aspect" of the present invention are not intended to be interpreted as excluding the existence of additional embodiments or aspects that also incorporate the recited features.

Referring to FIG. **1**, a turbomachine, such as a gas turbine, is schematically illustrated with reference numeral **10**. The gas turbine **10** includes a compressor **12**, a combustor assembly **14**, a turbine **16**, and a shaft **18**. It is to be appreciated that one embodiment of the gas turbine **10** may include a plurality of compressors **12**, combustor assemblies **14**, turbines **16** and/or shafts **18**. The compressor **12** and the turbine **16** are coupled by the shaft **18**. The shaft **18** may be a single shaft or a plurality of shaft segments coupled together to form the shaft **18**.

The combustor assembly **14** uses a combustible liquid and/or gas fuel, such as a natural gas or a hydrogen rich synthetic gas, to run the gas turbine **10**. The combustor assembly **14** includes a combustor chamber **20** that is in fluid communication with a fuel pre-mixer **22** that is in fluid communication with an airflow **24** and a fuel source **26**. The fuel pre-mixer **22** creates an air-fuel mixture, and discharges the air-fuel mixture into the combustor chamber **20**, thereby causing a combustion that creates a hot pressurized exhaust gas. The combustor chamber **20** directs the hot pressurized gas through a transition piece into the turbine **16**, causing rotation of the turbine **16**. Rotation of the turbine **16** causes the shaft **18** to rotate, thereby compressing air as it flows into the compressor **12**. The turbine section **16** has multiple rotatable wheels **17** on which a plurality of blades are mounted. In this example, three stages of turbine wheels **17** are shown, and each wheel would be paired with a stator vane stage (not shown). In general, turbomachines include, compressors, gas turbines and steam turbines.

FIG. **2** illustrates a perspective view of single turbine wheel **17**. The wheel **17** includes a series of circumferentially arranged dovetail slots **201**. A turbine blade (not shown) is inserted into each of these dovetail slots **201**. During service (or assembly) of the turbomachine **10**, the blades may need to be removed or installed. In a service example, the blades are removed and the used blades are either repaired and re-installed or just replaced with new blades. Turbomachines, such as gas or steam turbines, have large and heavy components. The wheel **17** with blades attached is one example of a heavy component, and this wheel is balanced to reduce vibrations. However, as the blades are removed from wheel **17**, the wheel's center of gravity changes, and the wheel will want to rotate in either a clockwise or counter-clockwise direction. This can present a serious safety hazard to people working on the turbine, as an unexpected wheel rotation can force a blade (or other wheel component) onto personnel. Therefore, it would be desirable to restrain the rotor from rotation during a blade removal or installation procedure. A fixture **210** for restraining the wheel **17** is the focus of this disclosure, and will be described in greater detail hereinbelow.

FIG. **3** illustrates a perspective view of the fixture **210** for restraining a wheel **17** of a turbomachine **10**. The fixture **210** includes a dovetail section **320** adapted for insertion into the dovetail slot **201** of the wheel **17**. The dovetail section **320** has a dovetail shaped profile or fir tree shaped profile, which include a plurality of ridges and valleys, adapted to interlock with corresponding notches or recesses in the dovetail slot **201** of wheel **17**. Typically, the peak height of each ridge decreases in height as the peaks become nearer to the bottom (radially inner portion) of the dovetail section. A mounting section **330** is located on top of and adjacent to, or formed integrally with, the dovetail section **320**. In one example, the dovetail section **320** and mounting section **330** are cast as, or machined from, a single piece of material, and this material may be 4140-HT (heat treated) high alloy tool steel as it has good strength, toughness, and mechanical properties. Alternatively, any other suitable material may be used as desired in the specific application. Fixture **210** also includes at least one coupling ring **340** attached to the mounting section **330**. The coupling ring **340** may be a hoist ring, shackle or other suitable coupling device. A fastener **342**, such as a shoulder head screw with washer, may be used to attach the coupling ring **340** to the mounting section **330**. The coupling ring **340** may be attached so that it swivels about an axial axis, and so that it can be oriented as shown in FIG. **3** or FIG. **4**, or any position in between the illustrated positions.

In use, the coupling ring **340** is secured to a stationary anchoring point via a restraint. To lock the fixture into the dovetail slot **201**, stops **350**, **360**, **450** are used on axial ends or axial faces thereof. The fixture **210** has a forward axial face (or end) **370** and an aft axial face (or end) **371**. The stop **350** is configured as a T-shaped stop and the top of the "T" extends past the outline of the dovetail slot **201**. In this manner, the stop **350** rests against a forward axial face of wheel **17** and prevents axial movement of the fixture. The stop **350** is attached to the dovetail section **320** by means of a fastener **352**, such as a shoulder screw or bolt. The aft axial face **371** has a fastener **362** and washer **360** that function as a stop. The washer **360** is sized so that it overlaps the dovetail slot boundary, and in so doing prevent axial movement of the fixture. When both stops **350**, **360** are installed, the dovetail section **320** is locked in the dovetail slot **201**, and the fixture will not slide out of the slot **201**.

FIG. **4** illustrates a perspective view of the fixture **210** for restraining a wheel **17** of a turbomachine **10**. Wheels **17** may have varying thicknesses. A thicker wheel may require a stop **350** as shown in FIG. **3**. However, for a thinner wheel a stop **450** may be used. Stop **450** is comprised of a plate having holes for one or more fasteners **452**. The fasteners **452** may be configured to screw into an axial face of mounting section **330** (as shown) and/or into dovetail section **320**. As an example only, the axial length of the dovetail section **320** and mounting section **330** may be sized to match the thinnest wheel of the target turbomachine. In this manner, T-stops **350** may be used to adjust the fixture to thicker wheels, and the stop plate **450** may be used on the thinnest wheel. The various stops **350**, **450**, **360** may also be fabricated from 4140-HT (heat treated) high alloy tool steel, or any other suitable material. In addition, both the aft end and the forward end have one or more internally threaded holes **481**, **482** adapted for securing fasteners. The mounting section **330** includes at least one internally threaded hole **483** adapted for attaching the coupling ring **340** to the mounting section **330**, and fastener **342** and an optional washer secures the coupling ring **340** to the mounting section **330** via the threaded hole **483**.

FIG. **5** illustrates an exploded, perspective view of the fixture **210** in a dovetail slot **201** of a wheel **17** of a turbomachine. The fixture **210** is inserted into the dovetail slot **201** and is restrained from moving radially or circumferentially. However, the fixture could slide out axially forward or aft. To prevent this, axial stops are installed. The forward axial stop **350** is attached/secured to the forward

side of the fixture. The aft axial stop **360** is then installed on the aft side of the fixture. When both stops are installed the fixture is locked to the wheel. The coupling ring **340** may then be attached to the mounting section **330**. It is to be understood that one or more coupling rings may be used, for example, one coupling ring on each axial face/end of the fixture, or one or more coupling rings may be located on the top (or radially outer surface) of the mounting section **330**, or any combination thereof. As shown in FIG. **5** dovetail section **320** has a straight profile adapted for use with a straight dovetail slot **201**.

FIG. **6** illustrates a top, cross-sectional view of the fixture located in a dovetail slot. The dovetail section **620** has an angled profile adapted for use with an angled dovetail slot **601**. The axial extending sides of slot **601** are not orthogonal to the axial faces thereof. FIG. **7** illustrates a top, cross-sectional view of the fixture located in a dovetail slot. The dovetail section **720** has a curved profile adapted for use with a curved dovetail slot **701**. This curved, axial-entry type of configuration may be used in steam turbines, or any other turbomachine as desired.

FIG. **8** illustrates a partial side view of the fixture installed in a wheel and connected to a stationary anchoring point on the turbomachine's casing. The stationary anchoring point **800** may include at least one counterbore assembly **810** having a coupling ring **812** attached thereto. The counterbore assembly **800** is adapted to be secured to a stationary structure **820**, such as a turbomachine casing, shell or flange. In the example shown, the stationary structure **820** is the bottom half of a turbine case. The counterbore assembly **810** has a counterbore insert **814** that has a portion adapted to extend into a hole **822** of the turbine case **820**. A head of the counterbore insert **814** is larger than the hole **822** diameter. The shaft portion of the counterbore insert (the portion that goes into the turbine casing hole **822**) includes an internally threaded hole that is configured for use with fastener **813**. Alternatively, the counterbore insert may be a cylindrical element having two opposing internally threaded holes, one for use with fastener **813** and another for a bolt (e.g., which would take the place of **814**). The fastener **813** connects the coupling ring **812** to the counterbore insert **814**, and therefore to the turbine case **820**. If desired a washer **815** may be interposed between the turbine case **820** and coupling ring **812**. The coupling ring **340** is secured to the coupling ring **812** on stationary anchoring point **800** by restraint **830**, which may be a chain, chain with come-along, cable or wire. Come-alongs may also be referred to as ratchet pullers, ratchet mechanisms or cable (or chain) pullers. Lever chain hoists or similarly functioning devices may be used as well for restraint **830**.

FIG. **9** illustrates a perspective view of the fixture **210** in a dovetail slot **201** of a wheel **17** of a turbomachine. The fixture **201** includes two coupling rings **340** and **940**. Coupling ring **940** is attached to a forward end of the mounting section and is located on a forward axial side of the wheel **17**, and coupling ring **340** is attached to an aft end of the mounting section and is located on the aft axial side of wheel **17**. This type of configuration allows two restraints **830** to be attached to the fixture. The restraints may extend in the same direction, or extend in generally opposing directions.

FIG. **10** illustrates a partial side view of the fixture **201** of FIG. **9** installed in a dovetail slot of wheel **17**, and the fixture is connected to two stationary anchoring points on the turbomachine's casing. The first stationary anchoring point **800** is connected to the fixture **210** via restraint **830** (shown by a dotted line). The second stationary anchoring point **800'** is connected to the fixture **210** via restraint **830'** (shown by a dotted line). The two stationary anchoring points **800**, **800'** may be on opposing sides of the turbine case. The restraints **830**, **830'** may be tightened by the use of a come-along **1010** or **1010'**. However, the restraints **830** do not need to be excessively tightened, as simply taking up the slack will be sufficient to prevent or restrain undesired wheel rotation. It is also to be understood that one or more coupling rings could be attached onto the top of the mounting section **330**.

FIG. **11** is a flowchart for a method **1100** for restraining a wheel **17** of a turbomachine. In step **1110** the fixture **210** is inserted into a dovetail slot **201** in the wheel **17**. The fixture **210** includes a dovetail section **320** adapted for insertion into the dovetail slot **201**, and a mounting section **330** located adjacent to, or formed integrally with, the dovetail section **320**. The mounting section **330** is adapted to connect to at least one coupling ring **340**. Step **1110** may also include placing a washer **360** over a fastener **362**, and then inserting the fastener **362** into a threaded hole in the dovetail section **320**. The washer is adapted to extend over or overlap an axial face of the dovetail slot **201**. In addition, at least one coupling ring **340** may be attached to the mounting section **330** or the fixture **210** in general.

In step **1120**, at least one counterbore assembly **810** is attached to a stationary structure **820**. In step **1130** a restraint **830** is connected to the coupling ring **340** and the at least one counterbore assembly **810**. Steps **1120** and **1130** may be repeated until the desired number of restraints are installed. Connecting step **1130** may also include attaching a come-along **1010** having a strap, chain **830** or cable to both the coupling ring **340** and the counterbore assembly **810** or other coupling ring **812** located on the stationary support. In step **1140**, the restraints are tightened to restrain or prevent the wheel **17** from rotating.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

The invention claimed is:

1. A fixture for restraining a wheel of a turbomachine, the fixture comprising:

a dovetail section adapted for insertion into a dovetail slot of the wheel;

a mounting section located adjacent to, or formed integrally with, the dovetail section;

a first coupling ring attached to an aft end of the mounting section;

a second coupling ring attached to a forward end of the mounting section; and

wherein the first coupling ring and the second coupling ring are adapted to be secured to a stationary anchoring point via a restraint.

2. The fixture of claim **1**, the dovetail section having a dovetail shaped or fir tree shaped profile adapted to interlock with corresponding notches or recesses in the dovetail slot of the wheel.

3. The fixture of claim **2**, both the aft end and the forward end having a threaded hole adapted for securing a fastener.

4. The fixture of claim 1, the dovetail section having one of:

a straight profile adapted for use with a straight dovetail slot, or

an angled profile adapted for use with an angled dovetail slot, or

a curved profile adapted for use with a curved dovetail slot.

5. The fixture of claim 1, the mounting section further comprising:

at least one threaded hole adapted for attaching the coupling ring to the mounting section, and wherein a fastener secures the coupling ring to the mounting section via the at least one threaded hole.

6. A fixture for restraining a wheel of a turbomachine, the fixture comprising:

a dovetail section adapted for insertion into a dovetail slot of the wheel, the dovetail section having a dovetail shaped profile or fir tree shaped profile adapted to interlock with corresponding notches or recesses in the dovetail slot of the wheel, the dovetail section having an aft end and a forward end, both the aft end and the forward end having a threaded hole adapted for securing a fastener;

a mounting section located adjacent to, or formed integrally with, the dovetail section, a first coupling ring attached to an aft axial face of the mounting section, and a second coupling ring attached to a forward axial face of the mounting section; the mounting section having threaded holes adapted for attaching the first coupling ring and the second coupling ring to the mounting section, and wherein coupling fasteners secure the first coupling ring and the second coupling ring to the mounting section;

wherein the first coupling ring and the second coupling ring are adapted to be secured to a stationary anchoring point via a restraint.

7. The fixture of claim 6, the dovetail section having one of:

a straight profile adapted for use with a straight dovetail slot, or

an angled profile adapted for use with an angled dovetail slot, or

a curved profile adapted for use with a curved dovetail slot.

* * * * *